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UNIVERSITY OF TARTU

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BARRIERS OF THE IMPLEMENTATION OF RENEWABLE ALTERNATIVES IN THE ENERGY SYSTEM OF KAZAKHSTAN

Bachelor Thesis

Supervisor: lecturer Helen Poltimäe

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This paper conforms to the requirements for a Bachelor Thesis

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(signature of the supervisor)

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I have written this Bachelor Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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Introduction

Kazakhstan is worldwide renowned for being a country obtaining an ample amount of natural resources. The state possesses 3 percent of global oil reserves (Vakulchuk & Overland, 2018), 4 percent of the world estimated coal reserves as well as gas reserves that are projected to last for 75 years (Karatayev & Clarke, 2014). Being tremendously contingent on the trade of these main natural resources, the Central Asian country has wedged itself in the economic condition in which exports of crude oil, gas and coal significantly contribute to GDP. In 2017 the oil & gas export comprised 50 percent of a state's gross domestic product (Fernandez, 2018), while in 2016 26 million tons of coal out of 98 million produced were supplied to Russia, Central Asia and several European countries (Aliyeva, 2017).

The colossal trading volume has induced a significant growth of the country's economy and, subsequently, the increase of food, water and energy consumption. The growth of the latter one precipitated adverse repercussion such as the rapid rise of carbon emissions. It is stated that in 2012 Kazakhstan generated the emissions in the amount of 224 million tCO_2e, being the world's biggest polluter per unit of GDP with the greenhouse gas (GHG) output equivalent to 6% of the EU's total one (IETA, 2015). The GHG emissions are mainly caused by the usage of coal-fired stations and gas-powered plants. Uyzbayeva, Tyo, and Ibrayev (2015) state that 71.1 percent of all power-generating plants utilize coal while the remaining 28.9 percent is split by gas and hydroelectric power. In 2009 Kazakhstan ratified the UN Framework Convention on Climate Change's Kyoto Protocol, under which the state has been obliged to diminish the GHG emissions by 15 percent by 2020 compared with the level of 1992 (Cleveland, 2016).

The growth of energy consumption has also led to the Kazakhstan's inability to meet the electricity demand. Besides the rapid development of the industrial sector, which accounts for 70% of the national electricity consumption, decrepit transmission networks induce the losses during the electricity transference at approximately 15%, though the real value may be greater (Karatayev & Clarke, 2014).

These ramifications may menace the country's economic fettle and nation's well-being if the government does not take robust actions to initiate the transition towards the utilization of renewable energy.

The author of this paper views renewable energy as an efficient solution to curb the potential threats associated with the increase of energy consumption. The same viewpoint is shared by Karatayev and Clarke (2014), who contend that the use of renewable alternatives will alleviate the problem of the increasing electricity demand coupled with environmental issues. It should be noted that the government has taken certain steps to stimulate the development of the renewable energy sector such as Kyoto Protocol, discussed above; the organization of EXPO – 2017, which main goal was to attract foreign investors to fund the renewable energy related projects (Segal, 2017); and inclusion of "green" policies in Strategy 2050 development plan (Elkin, 2015). Yet the contribution of renewable energy to the country's total energy generation remains extremely meagre with less than 1% of overall production (Karatayev & Clarke, 2014).

The aim of this paper is to discern what barriers of renewable energy implementation impede the diversification of the Kazakh energy system the most. In order to accomplish the research goal, the following tasks need to be completed:

- to present the theoretical framework for increasing the use of renewable energy;
- to analyze the previous literature done on the identification of barriers to renewable energy implementation;
- to conduct the survey and collect the answers to discern what current barriers of renewable energy implementation obstruct the diversification of the energy system in Kazakhstan to the greatest extent;

- to compare the results of the empirical analysis with the findings of previous literature;

The first part of the paper is presented as the theoretical overview of the framework behind renewable energy utilization, its advantages and disadvantages, and justification of its ascendancy over fossil energy. Additionally, the author analyzes previous studies linked with the barriers of renewable energy adoption.

The second part of the paper contains the empirical analysis which displays the author's own identification of barriers in Kazakhstan based on previous studies, the methodology used to discern these obstructions, and comparison analysis of findings presented by previous scholars and the ones provided by the author of this paper based on the collected survey responses.

Keywords: renewable energy, barrier, Kazakhstan, Analytical Hierarchy Process, AHP.

1. The theoretical framework for renewable energy utilization and the main barriers of its implementation

1.1. The theoretical arguments for implementation of renewable energy solutions

According to Sathaye et al. (2011), the concept of economic development is orchestrated with the increase of energy utilization and consumption as well as the rise of the GHG emissions. The same authors contend that renewable energy can decouple that correlation, promoting sustainable development of a state. As sustainable development is comprised of three elements such as economy, ecology and society, renewable energy solutions can greatly contribute to the goals of the sustainable concept (Sathaye et al., 2011):

- social and economic development;
- energy access;
- energy security;
- climate change mitigation and the reduction of environmental and health effects.

However, many individuals tend to equate the definitions of sustainable energy and renewable one. Zholdasbek and Tazhibayeva (2017) define renewable energy as sources of energy that are derived from the processes constantly occurring in the environment for the purpose of its technical application. Similar definition is provided by Shoaib and Ariaratnam (2016); however, the authors also claim that the renewable energy is equivalent to another term - sustainable energy, which they define as the energy generated and utilized in ways that synchronously maintain human development over the long period in all its social, economic, and environmental aspects. Shoaib and Ariaratnam (2016) contend, since fossil fuels such as coal, oil and gas are not considered to be sustainable as they are the primary sources of GHG emissions which perpetrate the human well-being, renewable energy is referred to be sustainable. However, Guest (2007) specifies that the term of sustainable energy covers both renewable energy and the rational use of it, affirming that the rational use of energy applies to all types of energy sources, both renewable and non-renewable. Thus, it can be implied that renewable energy itself can be non-sustainable, if used irrationally. The bright example of it can be the irrational use of water as a source of energy that can lead to the drought of the place where the water is extracted from. Since the concepts of renewable energy and sustainable development are highly aligned, the author of this paper proposes to define the renewable energy as the energy recurrently restored by nature and used for the purpose of its technical application in a rational way. Table 1 summarizes the aforementioned definitions of renewable and sustainable energy.

This paper scrutinizes four types of renewable energy sources: wind energy, solar energy, hydropower, and biomass. The mechanisms of energy production through the apparatuses such as wind turbines, photovoltaic systems, hydropower and biomass plants are distinct in nature. Wind turbines generate energy by assessing the wind speed which, if high enough to overcome the friction in the drivetrain, launches the rotor, also called blades, to spin, thus producing a power (Natural Resources Canada, 2001). Photovoltaic systems transform the sunlight into the electricity with the use of solar panels (Kumi & Brew-Hammond, 2013). Hydropower plants convert the potential energy of a mass of flowing water which, subsequently, turns a turbine that supplies the mechanical energy needed to drive a generator and create electricity (IRENA, 2012). Biomass energy is derived from plants that undergo the sunlight photosynthesis with solar energy stored as hydrocarbons in plant matter (Timmons, 2013).

Table 1

Definitions of renewable and sustainable energy

Author & Year	Definitions of renewable and sustainable energy
Shoaib and Ariaratnam (2016, p. 996)	• "Sustainable energy is defined as energy produced and used in ways that simultaneously support human development over the long-term in all its social, economic, and environmental dimensions." • "Renewable energy defined as the energy obtained from the continuous or repetitive currents of energy recurring in the natural environment."
Zholdasbek and Tazhibayeva (2017, p. 3)	• "Renewable energy – energy derived from sources that are inexhaustible on a human scale; the basic principle of the renewable energy usage is to extract it from the processes constantly occurring in the environment and to provide it for a technical use."
Guest (2007, p. 31)	• "Sustainable energy is a term that is used to cover both renewable energy and the rationale use of energy."

Source: composed by the author based on Shoaib and Ariaratnam (2016), Zholdasbek and Tazhibayeva (2017), Guest (2007).

The use of renewable energy alternatives is desired over fossil energy as the latter entails harmful effects on the environment. The pollution, caused by utilization of conventional energy, can generate an adverse impact on human health condition as well as impose other repercussions such as diminished agrarian yields and mutilation of forests and fisheries. Furthermore, approximately 70% of total worldwide GHG emissions are caused by the combustion of fossil energy sources, which subsequently hastens climate change (Johnsson, Kjärstad, & Rootzén, 2019). The main damage, though, is inflicted on human beings: IRENA (2016) states that 8 million people die because of the indoor and outdoor air pollution emitted by excessive energy consumption, transportation, and power generation. The same study contends that the estimate of external costs was in the range of 4.8% to 16.8% of global GDP and is expected to decrease to between 2.8% and 10% by 2030 due to the wider implementation of renewable energy sources. Owen (2006) defines the aforementioned external costs, or externalities, as particular environmental costs of production not divulged in the market cost of energy. According to IRENA (2016), the coal-based processes obtain the most adverse externalities, followed by oil. It is generally accepted that the renewable alternatives possess a competitive advantage over these types of fossil energy; though, the utilization of them also cause a negative impact on the health of nearby living dwellers and their disturbance.

Timmons (2013) states that biomass energy is one of a few renewable alternatives that will have to substitute nonrenewable fossil energy. However, the same author contends that energy production from forest biomass requires 71 times more land area than producing the same amount of electricity from solar photovoltaic panels. Timmons (2013) asserts that such abusive land use can lead to a negative externality characterized by a nitrogen fertilizer utilization with nitrate polluting groundwater aquifers which contribute to the excessive growth of plants in a body of water and greenhouse gas emissions. The GHG aspect of biomass is highlighted by Rabl and Spadaro (2016), though, the authors state that these emissions are not directly generated by the biomass energy but by the machinery utilized to transform the energy via steam turbine combustion or gas turbine gasification. Furthermore, Möllendorff and Welsch (2015) indicate the externality which is related more to the discomfort aspect – odor nuisance which causes the disturbance to the nearby living dwellers who have to endure an unpleasant scent generated by the biomass production and utilization.

Solar power is considered to be one of the most popular sources of renewable energy with many countries deploying concentrated solar power plants to satisfy electricity consumption. However, this renewable alternative also obtains external costs that affect the community. Mahlangu and Thopil (2018) contend that manufacturing aspect is deemed to be the main contributor in terms of the externalities: a solar salt and heat transfer fluids necessary for the solar panel deployment contain hazardous elements that can negatively affect flora and fauna of the place where the concentrated solar power plant is installed. The land use, which serves as a major externality for the biomass energy, is also required for the set-up of solar plants, which subsequently leads to the shortage of the cropland and contamination of it with dangerous elements. Additionally, Möllendorff and Welsch (2015) indicate that visual disturbances and glare effects also affect the comfort of dwellers who live nearby the solar power plants.

Dröes and Koster (2016) analyze the external costs of the wind turbines in the context of the Dutch housing market and assert that the abundance of the wind turbine farms in rural areas decrease prices of houses. It can be implied that the externalities that are caused by the wind turbines such as visual disturbances, sound disturbances, and flickering effects negatively influence the attractiveness of the living area for the potential buyers and diminish the interest of the public to dwell in the area located close to the wind farm. The same viewpoint is shared by Möllendorff and Welsch (2015) who indicate that visual and sound discomforts are deemed to be the major ones when one considers implementing this renewable alternative.

The study, conducted by Mattmanna, Logara, and Brouwe (2016), reveals that the main externalities related to hydropower are characterized by the diminished connectivity of aquatic systems or remolded flow regimes, highlighting that the reduced connectivity negatively influences fish and other animal species, while the altered flow regime causes fast changes in water temperature. However, the same study disregards visual disturbances of the hydropower plants as a significant barrier to its expansion in comparison with solar panels and wind turbines.

Table 2 summarizes the aforementioned external costs of renewable alternatives and fossil energy.

Table 2

Fossil energy and renewable alternatives' externalities

Type of renewable energy	Externality
Biomass	• Excessive land use • Nutrient pollution (eutrophication) • Steam turbine combustion/gas turbine gasification used in the biomass production • Odor nuisance
Solar power	• Hazardous elements used in solar energy deployment • Excessive land use • Visual disturbances/ glare effects
Wind power	• Decrease in house prices located near the wind turbine farms • Visual disturbances/ flickering effects • Sound disturbances
Hydropower	• Rapid water temperature changes caused by the altered flow regimes • The harmful impact of the reduced connectivity of aquatic systems on fish and other animal species
Fossil energy sources	• Adverse impact on human health condition caused by excessive air pollution • Diminished agrarian yields • Mutilation of forests and fisheries • GHG emissions • Climate change

Source: composed by the author based on Timmons (2013), Rabl and Spadaro (2016), Möllendorff and Welsch (2015), Mahlangu and Thopil (2018), Dröes and Koster (2016), Mattmanna et al. (2016), Johnsson et al. (2019), IRENA (2016).

To diminish the effects of the external costs, certain policies need to be enacted and actions – executed. Dröes and Koster (2016) indicate that negative externalities caused by wind turbines on the Dutch house pricing should be compensated either by the government or owners of the wind turbines. The authors also propose to build offshore wind parks, though, the cost of the construction is projected to be significantly high, and one needs to calculate whether the external costs of onshore wind turbines can be offset by building offshore ones (Dröes & Koster, 2016). The same proposal can be applied to the biomass production and concentrated solar power plants to minimize the external costs by installing renewable alternatives in the places where flora and fauna can be affected the least. A similar opinion is shared by Mattmanna et al. (2016) who claim that the construction of hydropower plants will have to be projected in places where they have as insignificant impact as possible on the adjacent landscape, vegetation and wildlife. Mahlangu and Thopil (2018) contend that the transportation of the components of solar panels contributes a large portion of emissions; thus, the local production of panel pieces needs to be established to reduce the negative effects.

Though the externalities generated by renewable energy are evident, the external costs generated by fossil energy have a more detrimental impact on the health of people and environmental sustainability. The use of renewable alternatives is seen to be an efficient way to significantly reduce the negative influence of conventional energy utilization but should be accompanied with policies aimed at diminishing unfavorable effects of externalities generated by the deployment and usage of green energy sources.

1.2 Literature review of the barriers impeding the implementation of renewable energy solutions

The successfulness of implementation of renewable energy in a country is highly contingent on the governmental authorities' ability to identify the existent barriers that can impede the process of the energy system transition. Kochtcheeva (2016) asserts that the development of renewable energy in developed countries is rapid thanks to:

- efficient policy implementations;

- vigorous patent activity of various developed countries such as Denmark, USA, Germany.

Sosa-Nunez (2016) supports the viewpoint of Kochtcheeva (2016) by stating that the countries like Austria, Germany, Sweden, Denmark show staunch commitment in implementing renewables in their energy systems and take exact steps to promote the change. The truth is that the initiatives taken by the aforementioned countries on increasing the share of renewable energy have been ongoing since 1990s such as the imposition of the carbon tax (IRENA, 2019). Sosa-Nunez (2016) also contends that the barriers of the developed countries are not related to the inefficiency of political structures or economic frailty; in fact, the main concern of developed countries is how to execute the enacted policies more efficiently to speed up the process of the renewable energy adoption.

The studies chosen by the author examine the plight of renewable energy development and existent barriers that are intrinsic to this sector in India, Barbados, Chile, Nepal, and Kazakhstan. Being referred as the developing states, the aforementioned countries also show the eagerness to adopt renewables in their energy systems: Chile plans to rely on clean sources for 90 percent of its electricity need by 2050 (Londoño, 2017); Nepal aims to decrease its imports of petroleum and improve the quality of life (Surendra, Khanal, Shrestha, & Lamsal, 2011); Barbados sets the goal to produce 29 percent of electricity from renewable sources by 2029 (Espinasa et al., 2016). However, prevalent barriers such as political and economic instabilities as well as poor institutional functioning hinder these states to develop renewable energy system, thus, are chosen to find out what exact obstructions impede the process and what measures are needed to be taken to eliminate them. Additionally, the author chose the aforementioned papers as most of the articles about renewable energy barriers are review ones and do not provide the readership with the empirical analysis accompanied with actual results. The paucity of literature limited the number of works for examination and prompted to select the research studies with solid empirical findings and presume to some extent a similar scenario for Kazakhstan for identifying the obstructions of non-conventional energy.

The author gives a general overview of previous researches: what countries are scrutinized and how many barriers are identified by the respective authors. Additionally, this paper discusses methodologies the scholars used in their works as well as presents similarities and dissimilarities in the identification of barriers between the above-mentioned studies.

Luthra, Kumar, Garg, and Haleem (2014) identify 28 barriers of the implementation of renewable energy in India based on the literature review. Ghimire and Kim (2018) analyze the current obstacles of renewable energy adoption in Nepal and, unlike Luthra et al. (2014), recognize 22 current barriers. Karatayev, Hall, Kalyuzhnova, and Clarke (2016) identify the greatest number of renewable energy hindrances in Kazakhstan – 38.

Unlike the works done on Nepal, India, and Kazakhstan, Wyllie, Essah and Ofetotse (2018) narrow the topic of their research paper, scrutinizing the barriers impeding the implementation of the solar energy in Barbados. Similarly, Nasirov, Silva and Agostini (2015) take a different angle on viewing the problem of the renewable energy underdevelopment in Chile by examining the investor's perspective of the perceived obstructions of the renewable energy implementation. Wyllie et al. (2018) identify 17 barriers, while Nasirov (2015) identify 18.

Some of the scholars (Luthra et al., 2014; Karatayev et al., 2016; Ghimire and Kim, 2018) use the analytical hierarchy process (AHP) methodology to reveal which hindrances are reckoned by the relevant stakeholders to be the most important.

The AHP methodology estimates criteria weights to juxtapose and rank the alternatives in respect of a certain criterion in a pair-wise mode, thus, help a stakeholder to make the right choice. This framework is referred as a Multi-Criteria Decision Method tool, which is used to evaluate, in above-mentioned cases, the cruciality of barriers (Luthra et al., 2014; Ghimire & Kim, 2018). The methodology was firstly introduced by Thomas L. Saaty as an effective tool to quantify the intangible factors to further make better decisions (Saaty, 1980; Saaty, 2008). One of the steps that Saaty (2008) presents in a detailed instruction of making a good decision is the establishment of the decision goal placed on the top of the hierarchy process; then, the objectives from a broad perspective positioned on the intermediate to the lowest levels. In the context of the topic this paper revolves around, the structure of the "best decision" tree of the above-mentioned scholars is approximately set in the following way:

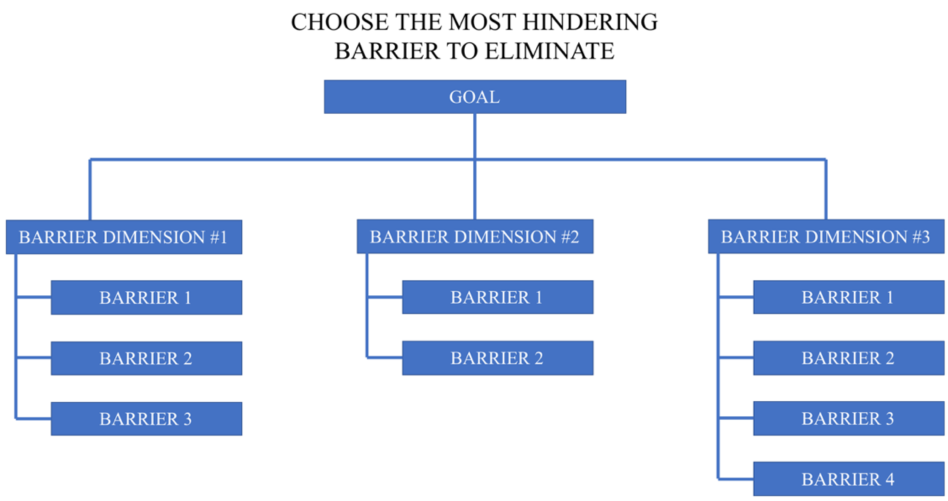

Figure 1. Best decision in the context of eliminating the most important barrier hindering the implementation of renewable energy

Source: composed by the author based on Saaty (1980).

The compilation of the pairwise comparison matrixes with the respective weight and priority assignments is explained in the empirical part of this paper.

Besides the AHP method, the sensitivity analysis is also carried out in "Barriers to renewable/sustainable energy technologies adoption: Indian perspective" (2014) for the purpose of model verification, since the data collected in Multi-Criteria Decision Method problems can be vague and inconstant. Luthra et al. (2014) state that the sensitivity analysis ascertains the slightest change in the current weights of the criteria, which can alter the existent ranking of the given options.

The research design applied to the works of Wyllie et al. (2018) and Nasirov et al. (2015) respectively is different from the one used in the previously discussed papers. The scholars of both works utilize surveys to collect data regarding renewable energy barriers. Besides the questionnaires, Wyllie et al. (2018) also hold the interviews with relevant stakeholders such as renewable energy technical experts, energy and non-governmental organizations' representatives. Likewise, Nasirov et al. (2015) carry out face-to-face interviews with investors to further discuss the results of the research as well as provide the readership with the summary of respondents they surveyed: 128 people involved in small hydro, wind, solar, biotechnologies, and geothermal spheres. The scholars also specify that the descriptive analyses of the survey data are carried out with the Quota Sampling Method. The advantage of the Quota Sampling Method lies in its ability to discern group dissimilarities or to examine characteristics of a certain subgroup; however, the method also obtains certain downsides such as the inability to provide generalizable estimates of the target population because it uses the nonprobability samples (Nasirov et al., 2015).

The above-mentioned studies examine different barrier dimensions which group a number of relevant renewable energy obstructions. Table 3 shows what dimensions are used by the previously discussed authors. As it can be seen, all scholars assess the Economic, Social and Cultural, and Technical dimensions, and it implies that renewable energy impediments classified under these groups are reckoned to be crucial for the evaluation. However, classifications such as Political, Market Failure, and Institutional ones are considered only by some authors, presumably, because their effects on the renewable energy sector in certain countries are not substantially significant to be scrutinized. Additionally, the classifications of barriers bear different denotations in the works of above-mentioned scholars. However, someone may notice that similar to the meaning barriers are classified under different dimensions (see Appendix A). Lack of skilled manpower is one of the examples when the barrier is grouped under either technical or administrative classification. That is to say, Ghimire & Kim (2018) and Nasirov et al. (2015) believe that the issue of the lack of skilled manpower arouses from the frailty of the educational system, which is supposed to be resolved by governmental bodies.

Table 3

Barrier dimensions examined in the previous studies

Dimension	Author & Year				
	Luthra et al. (2014)	Nasirov et al. (2015)	Karatayev et al. (2016)	Wyllie et al. (2018)	Ghimire and Kim (2018)
Economic & Financial	5 barriers	8 barriers	4 barriers	4 barriers	5 barriers
Political	3 barriers	N/A	N/A	4 barriers	4 barriers
Market Failure	4 barriers	N/A	3 barriers	N/A	N/A
Ecological & Geographical	3 barriers	N/A	N/A	N/A	2 barriers
Institutional	N/A	1 barrier	3 barriers	N/A	4 barriers
Social & Cultural	3 barriers	3 barriers	3 barriers	3 barriers	3 barriers
Technical	7 barriers	6 barriers	4 barriers	6 barriers	4 barriers

Source: composed by the author based on Luthra et al. (2014), Nasirov et al. (2015), Karatayev et al. (2016), Ghimire and Kim (2018), and Wyllie et al. (2018).

Other scholars (Luthra et al., 2014; Karatayev et al., 2016; Wyllie et al., 2018) do not explain why they put the shortage of trained people under the technical barrier dimension, but it can be implied that this issue is to be specifically related to the renewable energy development, since the skills and knowledge required for executing the project have to be taught by qualified experts specialized in the field and cannot be derived only from educational institutions.

Though, one can see the similarities of both barrier dimensions and their hindrances in the works of the aforementioned scholars, the evident differences in indicated barriers are still prevalent and connected with specificity of the chosen state. For instance, the dimension related to the geography is mentioned in the works of Luthra et al. (2014) and Ghimire and Kim (2018), though, none of the barriers categorized under that classification match with each other. Moreover, Ghimire and Kim (2018) recognize only geographical barriers with the transportation issue and scattered households grouped under the classification, while Luthra et al. (2014) contend that the consequences the implementation of renewable energy brings are viewed as adverse by the community. The latter scholars exemplify the ecological issues with the wind power generating visual and sound disturbances and the solar power resulting in immoderate land use, water use and the utilization of perilous materials in manufacturing.

It can be also noticed that Karatayev et al. (2016) do not consider political barriers as significant ones that can affect the development of renewable energy implementation: the authors provide the readership with the institutional barriers that pertain to the usual features of the inefficient governmental system: lack of a legal and regulatory framework, long and complicated bureaucratic procedures regarding the issuance of building permits, lack of expertise and awareness within authorities; however, none of them has a direct connection to the activity of political bodies regarding the renewable energy development. In contrast, other scholars (Luthra et al., 2014; Ghimire and Kim, 2018; Wyllie et al., 2018) signify the importance of the inclusion of political barriers as they reckon that the stability of the country's political system, as well as its ability to propose and enact relevant policies, have a direct influence on the implementation of the renewable alternatives in the energy system.

Luthra et al. (2014), Ghimire and Kim (2018), and Karatayev et al. (2016) provide the readership with the ranking of barriers within a certain dimension to reveal the greatest obstacle in its relative classification. They also display the overall ranking of barriers; however, unlike Ghimire and Kim (2018), Luthra et al. (2014) and Karatayev et al. (2016) also carry out the overall ranking of dimensions, pinpointing which classification holds the greatest influence in terms of impeding the implementation of renewable energy. The slight correspondence of results in two studies can be detected: political instability, denoted by Ghimire and Kim (2018) and lack of political commitment, suggested by Luthra et al. (2014) represent the greatest obstacles in their respective barrier dimensions. These hindrances also take the first place in the overall ranking of barriers and, thus, imply that the successfulness of renewable energy implementation in India and Nepal is highly dependent on the condition of the political infrastructure: the ability of opposite governmental parties to come to the consensus in different political aspects and enact efficient policies defines the country's preparedness to realize the ambitions aimed at developing the renewable energy system. However, the results of the above-mentioned scholars differ when it comes to the ranking of barriers under the Economic dimension. Luthra et al. (2014) state that High Initial Capital Costs serve as a major hindrance to the renewable energy implementation, while Ghimire and Kim (2018) identify the Lack of End Use (Insufficient Daytime Demand) as the greatest obstruction in economic terms.

The authors of the Kazakh study ascertain that the government fossil fuel priority is the main barrier that obstructs the development of the renewable energy system in Kazakhstan: the state has been providing subsidies equivalent to 5% of its GDP for the fossil fuel extraction as well as has been planning to increase the coal production and build new nuclear and coal-fired plant stations to expand the electricity generation capability. These initiatives aimed towards fossil fuel expansion occupies most of the institutional capacity of the Kazakh energy governance and, simultaneously, damage the development of renewable energy. (Karatayev et al., 2016)

Regarding the overall ranking of the dimensions, Luthra et al. (2014) identify the Ecological & Geographical classification as the most influential one in terms of the impediment of renewable energy implementation. It should be noted that 2 barriers from that dimension, ecological issues and scarcity of natural & renewable resources, take second and third places respectively in the overall ranking of barriers after the lack of political commitment. The sensitivity analysis shows that the increase and decrease of values of dimension weights with respect to Ecological & Geographical classification reveal a high impact of the ecological dimension on other barrier classifications and infers that the removal of barriers grouped under Ecological & Geographical classification will entail the prospective elimination of other remaining dimensions.

Karatayev et al. (2016) discern that the Economic & Financial barrier dimension to be the most hindering one in terms of the renewable energy development with low electricity tariffs taking the third place in the overall ranking barriers. It can be related to the Kazakhstan’s aggressive fossil fuel expansion and neglect of renewable energy initiatives. The same scholars also state that the Risky Business Environment is deemed to be the most hindering obstruction when it comes to Institutional barriers.

Ghimire and Kim (2018) state that poor R&D facilities significantly impede the development of renewable energy projects in Nepal. The situation is different in Kazakhstan where a lack of infrastructure characterized by the low availability of energy storage systems stagnates renewable energy deployment progress (Karatayev et al., 2016).

Wyllie et al. (2018) discover that the barriers grouped under the economic classification are reckoned to be the most hindering ones: the first 3 places are taken by Investment Challenges and Concerns, State of the Economy, and Knowledge and System Costs respectively; the economic obstructions are followed by political barriers, such as Lack of Policy and Regulatory Framework and Dependence on Fossil Fuel for Revenue, and a technological one – Research and Development. Result of Nasirov et al. (2015) research shows that investors are mostly perturbed with technological and infrastructural underdevelopment of Chile to deploy renewable energy projects: Grid Connection

Constraints and Lack of Grid Capacity and Longer Processing Times for Large Number of Permits take the first 2 places in the overall ranking of barriers. Table 4 summarizes the previous literature discussed above.

Table 4

Summary of the literature review

Author & Year	Country	Methodology	Results
Luthra et al., 2014	India	AHP Sensitivity analysis	• Ecological and Geographical dimension is the most hindering one • Lack of Political Commitment is ranked first in the local ranking and overall barrier ranking • High Initial Capital Costs – the most obstructing barrier in the Economic & Financial dimension
Nasirov et al., 2015	Chile	Survey (QSM) Interviews	• Grid Connection Constraints and Lack of Grid Capacity – the most impeding barrier
Karatayev et al., 2016	Kazakhstan	AHP	• Economic and Financial dimension is ranked to be the most hindering one • Government Fossil Fuel Priority is ranked first in the global ranking • Risky Business Environment is the most impeding obstruction under Institutional dimension • Low Electricity Tariffs are the major obstruction in the Economic Barrier dimension • Lack of Infrastructure is the most impeding obstruction under Technical dimension
Ghimire and Kim, 2018	Nepal	AHP	• Political instability is ranked first in the local ranking • Lack of R&D facility is the most impeding obstruction under Technical Barriers dimension • Lack of End Use is ranked first in the Economic Barriers dimension
Wyllie et al., 2018	Barbados	Interviews Questionnaire surveys	• Dependence on Fossil Fuel for Revenue serves as one of the major hindrances to the solar energy system deployment

Source: composed by the author based on Luthra et al. (2014), Nasirov et al. (2015), Karatayev et al. (2016), Ghimire and Kim (2018), and Wyllie et al. (2018).

It is implied that political and economic barriers are common and significantly stagnate the development of renewable energy development. Though the barriers themselves are distinct from each other, and it is implied that different economic and political factors and conditions entail dissimilar renewable energy barriers belonging to the same dimension. Technical barriers also play a huge role in the non-success of deployment and utilization of non-conventional energy as the poor infrastructure and atrocious grid system does not allow to effectively transmit the full energy to the desired destination or store the energy for the further usage.

2. Empirical analysis on the identification of renewable energy barriers in Kazakhstan

2.1. Methodology for empirical analysis

The initial barrier identification for further survey construction was based on Karatayev et al.'s (2016) work since the authors' research revolves around renewable energy impediments in Kazakhstan, and the credibility of the barrier recognition was reckoned to be on the sufficient level as the study mentions the analysis of the extant reports from National bodies and agencies, academic and grey literature as well as the carry-out of semi-structured interviews with 23 respondents to get their perceptions of the prevalent hindrances. However, certain adjustments were done to the Karatayev et al.'s (2016) version of the barrier identification since the author of this paper believes in the necessity of including political barriers. The same viewpoint is shared by Luthra et al. (2014), Ghimire and Kim (2018), and Wyllie et al. (2018) who use political barriers in their evaluations.

The initial version of the survey was given to the expert who has consulted the energy company during the recent wind turbine installation project. His review and comments on the survey prompted the author of this paper to re-evaluate the barriers that were included in the questionnaire. The reason for this change was the evident relationship between the barriers that Karatayev et al. (2016) assessed for the study. For Market Failure classification, the same authors evaluate the Fossil Fuel Priority and Fossil Fuel Subsidies, and it is implied that if the state is inclined to promote the fossil fuel production, it will subsidize companies that produce this type of energy. For Economic and Financial dimension, Karatayev et al. (2016) assess the Lack of Financial Resources and Weak Financial Support, but the unavailability of sufficient funds may cause the inability of the state to support renewable energy projects.

As some of the barriers were eliminated due to the prevalence of the relationship in Karatayev et al.'s (2016) work, the author of this paper added some barriers to certain dimensions based on the previously discussed studies. Additionally, the expert proposed the renewable energy obstructions that are not mentioned in the treatises of the previous scholars. Having a comprehensive experience of consulting companies operating in the energy sector, he suggested to include the obstacles such as Long Payback Period and Low Purchasing Power as these hindrances have been posed as common ones when assessing the viability of renewable energy project.

The survey was distributed in two languages: English and Russian. It was translated in the following manner: English-Russian-English, to discern whether the translation did not distort the meaning of the barrier. The language rendition involved the academic from Kazakh Ablai Khan University of International Relations and World Languages to avoid the aforementioned issue. However, during the discussion with the abovementioned expert, it was advised to modify the wording of certain renewable energy hindrances in the Russian language to better convey the denotation and, thus, minimize the survey abandonment rate. These modifications led to the new list of barriers that were used in the final version of the survey. Table 5 presents these renewable energy impediments classified under their respective dimensions.

Table 5

Barriers and their classifications used in the final version of the survey

Barrier classification	Barrier	Source
1. Market Failure	1.1. Fossil Fuel Priority (oil, gas, coal)	Karatayev et al. (2016)
	1.2. Lack of Consumer Awareness about Renewable Alternatives	Luthra et al. (2014) Ghimire and Kim (2018)
2. Economic	2.1. Long Payback Period	Expert interaction
	2.2. High Capital Investment	Luthra et al. (2014) Nasirov et al. (2015) Karatayev et al. (2016) Ghimire and Kim (2018)
	2.3. Transmission and Distribution Losses of Electricity for the Particular Period	Luthra et al. Expert interaction
3. Technical	3.1. Complexity of Using New Technology to Deploy Renewable Alternatives	Luthra et al. (2014) Expert interaction
	3.2. Lack of R&D to Improve the Usage of Renewable Alternatives	Luthra et al. (2014) Ghimire and Kim (2018) Wyllie et al. (2018)
	3.3. Lack of Opportunities for the Professional Training	Expert interaction
4. Institutional	4.1. Weak Legal and Regulatory Framework	Karatayev et al. (2016)
	4.2. Risky Business Environment	Karatayev et al. (2016)
	4.3. Complicated Bureaucratic Procedures	Karatayev et al. (2016)
5. Social	5.1. Lack of Consumer Awareness about Renewable Alternatives	Ghimire and Kim (2018)
	5.2. Low Purchasing Power	Expert interaction
6. Political	6.1. Lack of Political Commitment	Luthra et al. (2014)
	6.2. Lack of Adequate Legislative Framework	Expert interaction
	6.3. Lack of Public Interest Litigations Supporting Renewable Energy Projects	Luthra et al. (2014) Expert interaction

Source: composed by the author based on Luthra et al. (2014), Karatayev et al. (2016), Ghimire and Kim (2018), and expert's contribution.

One can notice that the Lack of Consumer Awareness about the Renewable Alternatives appears in both Market Failure and Social Barriers dimensions. Luthra et al.

(2014) contend the lack of consumer awareness comes from the market imperfection characterized with the poor access to information in comparison with the conventional energy technologies, and this leads to the ignorance of people about costs and benefits of using renewable alternatives. However, Karatayev et al. (2016) assert that this barrier needs to be classified under the Social Barriers dimension as the lack of information about the renewable alternatives leads to the lack of interest and commitment to promoting them. The author of this paper reckons that this hindrance, obtaining binary features of each dimension, can fall under two classifications.

The number of survey respondents for this paper is 52 which is significantly greater than the number of respondents in Karatayev et al.'s (2016) work which is equal to 23. The sample includes renewable energy experts that work in the academic field and energy sector (see Appendix B). Some of the respondents are currently/were previously involved in the renewable energy projects, particularly the installation of wind turbines in Akmola, Kyzylorda, and Zhambyl regions. The author of this paper personally knew people involved in renewable energy projects. Thanks to referrals, the scope of survey distribution to the relevant individuals expanded. Additionally, the author searched for professors and academic practitioners specialized in the renewable energy and environmental studies in AUES (Almaty University of Power Engineering and Telecommunications), KNU (Kazakhstansko-Nemetskiy Universitet), KazNU (Al-Farabi Kazakh National University), and KIMEP University. 78 questionnaires were sent out in total, and it is implied that the response rate equals to 67%.

The methodology chosen by the author of this paper is the Analytical Hierarchy Process (AHP) analysis. It is carried out to discern which barrier in its respective barrier dimension is the most hindering one in terms of renewable energy deployment based on the experts' criteria selection. According to Oğuztimur (n.d.), the major advantages of this methodology are the ability to provide a simple model for a problem and the reliance on the judgements of experts from diverse backgrounds which endows to evaluate the problem from multiple perspectives. The same author also brings out the shortcomings of the AHP analysis which are the complex computational requirement and increase of pair comparisons caused by the growth of a number of hierarchy levels. However, the complex calculation is solved with the Excel software which is discussed later in this paper while the global ranking, which would represent the issue of a high number of pair comparisons, is not carried out for the particular reasons explained later in this paper.

The structure of the AHP analysis is identical to the general structure, proposed by Saaty (1980), and previous works done by Luthra et al. (2014), Ghimire and Kim (2018) and Karatayev et al. (2016), who provide a more topic-tailored approach towards the methodology. The analysis consists of several steps:

- Step 1: establishing the hierarchical structure around the barriers and their relevant categories
- Step 2: composing the pair-wise comparison questionnaires for stakeholders to give their assessments based on a nine-point scale
- Step 3: compiling a pair-wise comparison matrix in respect of barriers in each category based on the data collected from questionnaires
- Step 4: calculating the weight

The first step requires to decompose the indicated barriers and its classifications into a hierarchical tree which includes 3 levels (Saaty, 1994):

- Level 1 – Goal: ranking the renewable energy barriers
- Level 2 – Barrier dimension
- Level 3 – Barrier within the dimension

Figure 2 serves as a visual representation of the first step and levels discussed above.

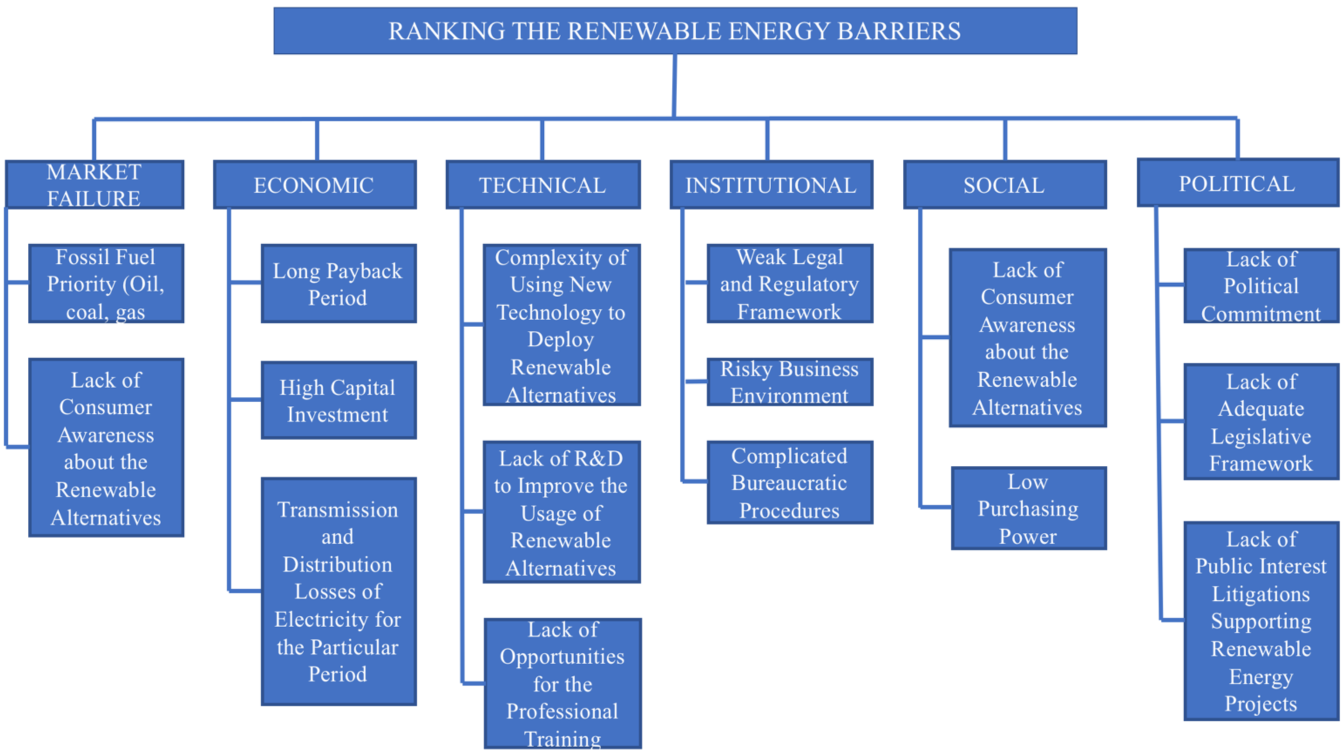

Figure 2. The hierarchical tree in the context of renewable energy barriers and their respective dimensions

Source: composed by the author based on Saaty (1994).

The survey, construction of which is required in the second step, consists of 30 questions divided by 6 sections, each represented by the barrier classification. A respondent was expected to choose among the given options which barrier was more hindering in terms of deployment of renewable energy alternatives. If the respondent chose one barrier over another one, he would then have to rate the intensity of hindrance based on the scale proposed by Saaty (2008) with modifications in value definitions. Table 6 shows the scale used to rate the intensity of favored barrier over another one. However, if the respondent chose the option that one barrier is equal to another one in terms of intensity of hindrance, the value of 1 would be assigned to both of the barriers in the matrix required in the third step (see Appendix C for the full survey).

Table 6

The rating scale used in the survey

Intensity of hindrance	Definition
2	Weak hindrance
3	Moderate hindrance
4	Value between 3 and 5
5	Strong hindrance
6	Value between 5 and 7
7	Very strong hindrance
8	Value between 7 and 9
9	Extreme hindrance

Source: composed by the author based on Saaty (2008).

When the respondent assigns the value of hindrance intensity to the favored barrier, the reciprocal of that value is automatically assigned to another barrier. For instance, if the respondent selects the option that Fossil Fuel Priority is more hindering than Lack of Consumer Awareness and rates the former barrier at the value of 6, then the latter one will be assigned with the score of $\frac{1}{6}$. Consequently, the matrix, construction of which is required in the third step, is built in the following manner:

$$Market\ Failure: \begin{pmatrix} & MF1 & MF2 \\ MF1 & 1 & 6 \\ MF2 & \frac{1}{6} & 1 \end{pmatrix},$$

where the relation between the same barriers, e.g. MF1 and MF1, is automatically assigned with the value of 1.

The weight calculation indicated in the fourth step is done in MS Excel and is necessary to discern the ranking of barriers within their respective dimensions. It should be noted that the global weighting is not carried out for this work as the barrier dimensions were not evaluated against each other in terms of the hindrance of renewable energy implementation. The inclusion of dimension assessment in the survey would increase the probability of unwillingness of respondents to complete the questionnaire since the matrix for barrier classifications is 6x6 which would increase the number of questions to 60 compared to 30 in the final version of the survey. The dimension assessment would enable to discern what barrier is reckoned to be the most hindering one among all renewable energy impediments evaluated for this paper; however, the author's goal is to find the most hindering obstacle within its group as curbing barriers in each group represents a rational approach to a solution rather than alleviating the issues in the order from the most hindering obstruction to the least one.

The principles of calculation in MS Excel are based on works of Goepel (2013) and Perzina and Ramík (2014). First, the author of this paper computes the matrixes based on the answers provided by the respondent. Second, the geometric mean of responses is calculated to determine the overall matrix of barriers within the dimension. Third, the matrix normalization is carried out by totaling the number in each column and computing the arithmetic mean which, in turn, is a weight of respective barrier.

To make sure that the priority of matrix components is consistent, the maximum eigenvector or relative weights are computed. Consequently, the calculation of the consistency index (CI) for each matrix order *n* needs to be executed using the following formula:

$$CI = (\lambda \max - n)/(n-1)$$

Based on CI and Random Consistency index (RI), the consistency ratio (CR) is computed with the following formula:

$$CR = (CI/RI) \times 100\%$$

where RI differs depending upon the order of matrix: in the case of this paper, the RI for 3x3 matrix is 0.58. Consistency ratio must be less than or equal to 0.1; if not accomplished, the revision of calculations needs to be carried out. The calculation of consistency for 2x2 matrix is not needed as it is consistent by construction. (Saaty, 1980)

2.2. Analysis of results on the ranking of renewable energy barriers

The results for each specific dimension obtain the evident discrepancy in terms of percentage of weight used by the author to rank the intensity of hindrance of one barrier over another one in its relevant classification. One can see that most of the experts are strongly disposed to the opinion that Fossil Fuel Priority has a dominant position over Lack of Consumer Awareness in terms of renewable energy obstruction power. The same ranking-wise disparity can be detected in the Economic dimension with High Capital Investment outracing its peer non-conventional energy obstructions in the bracket. The political dimension also reveals the disposition of experts to consider Lack of Political Commitment as the most hindering impediment in its group with the precipitous weight change from the first to the last barrier of division. When it comes to evaluation of weight discrepancies between the renewable energy obstructions in Technical dimension, one can state that there is slight deviance, and it is implied that the hindrance intensity of these barriers is quite comparable. The same reckoning is applied to Institutional and Social classifications. Figure 3 supports the above-mentioned statements by displaying the ranks and weights of each examined barrier in its respective dimension.

As previously discussed, Fossil Fuel Priority (oil, gas, coal) has been found as the most hindering barrier in the Market Failure classification with the weight of 69% (see Appendix D). This finding can be linked to the Fossil Fuel Subsidies barrier ranked first in Karatayev et al.'s (2016) work since the fossil priority can lead to the increase of subsidies provided to companies producing this type of fuel. However, the results differ when compared to Luthra et al.'s (2014) ones because the scholars indicate that the Lack of Consumer Awareness is deemed to be hindering the most in the Market Failure dimension, whereas the same factor is weighted the lowest in this paper.

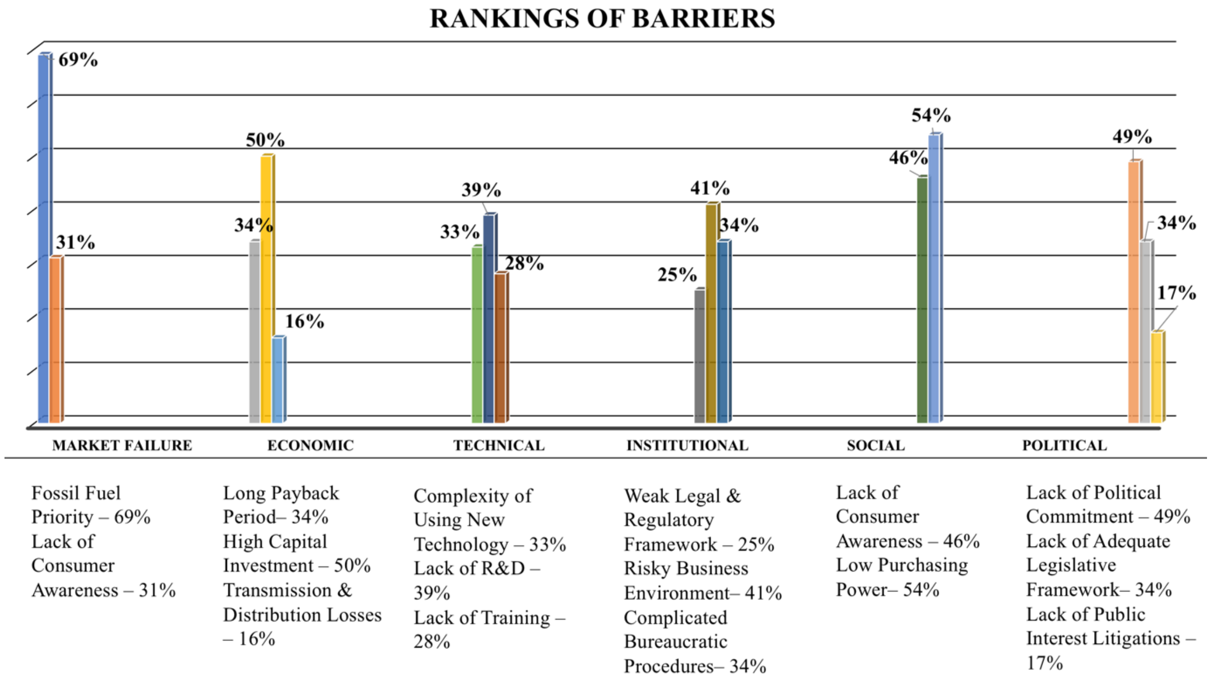

Figure 3. Rankings of barriers

Source: composed by the author

The result of Economic dimension with High Capital Investment, which was ranked first in terms of hindrance of renewable energy implementation with the weight of 50% (see Appendix E), is different from the one gained in the Karatayev et al.'s (2016) work which indicates that Low Electricity Tariffs are the major obstruction of the Kazakh renewable energy sector in the economic terms. However, the correspondence in results can be found between the author of this paper and Luthra et al. (2014) as the latter scholars indicate that High Initial Capital Costs hamper the implementation of renewable energy in India the most.

Lack of R&D to Improve the Usage of Renewable Alternatives has been found as the most hindering barrier in the Technical Barriers dimension with the weight of 39% (see Appendix F). This finding is consonant with the result gained by Ghimire and Kim (2018) and Wyllie et al. (2018) who specify that Lack of R&D is posed to be the most obstructing to the implementation of renewable alternatives in Nepal and Barbados respectively. It implies that there is a huge necessity for developing countries to invest more in research & development to stimulate the deployment of renewable alternatives.

The assessment of Institutional barriers reveals that Risky Business Environment is ranked first, thus, considered to be the main barrier of its group (see Appendix G) that impedes the deployment of renewable alternatives. The same reckoning is drawn by Karatayev et al. (2016), and it implies that part of the reason why renewable energy projects have been rarely launched in Kazakhstan is the high probability of project failure due to economic and governmental aspects. However, Complicated Bureaucratic Procedures are deemed to be the least hindering barrier in the work of the above-mentioned scholars while the experts of this paper ranked it second with the small difference in weights between the first and second places.

Lack of Consumer Paying Capacity assessed by Ghimire and Kim (2018) and Low Purchasing Power evaluated in this paper are both ranked first (see Appendix H) in terms of renewable energy implementation obstruction. As the cost of generating the clean energy is still higher than the cost of producing it by using the fossil fuel, people from developing countries do not promote the implementation of renewable alternatives because it will increase the expenses. Governments need to take certain measures, such as incentive provisions or partial reimbursement of electricity expenses, to promote the usage of electricity derived from renewable energy sources.

Lack of Political Commitment has been found as the most hindering barrier in the Technical Barriers dimension with the weight of 49% (see Appendix I). The same ranking position result was gained by Luthra et al. (2014) and Ghimire and Kim (2018), and it is implied that the success of renewable energy deployment and utilization is greatly contingent on the state of the political infrastructure which includes the capability of clashing governmental parties to arrive at the consensus in various political aspects and implement effective policies. This determines the state's readiness to actualize the ambitions targeted at developing the renewable energy system.

Table 7 summarizes similarities and differences of results between the works of previous scholars and this paper.

Table 7

Comparison of empirical results of the previous literature and this study

Theme	Empirical results of the previous literature	Empirical results of this study
Economic Barrier	• Low Electricity Tariff to be the most hindering barrier in the Karatayev et al.'s (2016) work • High Initial Capital Costs – the most obstructing barrier in the Luthra et al.'s (2014) study	• High Capital Investment to be the most impeding obstacle in the economic dimension
Market Failure Barriers	• Fossil Fuel Subsidies – the most hindering barriers in the Karatayev et al.'s (2016) work • Lack of Consumer Awareness - the main impediment in the Market Failure dimension in the Luthra et al.'s (2014) paper	• Fossil Fuel Priority is the most impeding obstacle under the Market Failure dimension, while Low Consumer Awareness is the least one
Technical Barriers	• Ghimire and Kim (2018) and Wyllie et al. (2018) specify that Lack of R&D is reckoned to be the most hindering barrier	• This study also identifies Lack of R&D as the most impeding obstacle
Institutional Barriers	• Karatayev et al. (2016) assert that Risky Business Environment is the most hindering barrier	• Likewise, the survey respondents ranked Risky Business Environment as the first in terms of impeding the implementation of renewable energy alternatives in the Institutional dimension
Social Barriers	• Lack of Consumer Paying Capacity is ranked first in the Ghimire and Kim's (2018) study	• Low Purchasing Power is deemed to be the most hindering obstacle in Kazakhstan as well
Political Barriers	• Lack of Political Commitment and Political Instability are ranked first in the Luthra et al.'s (2014) and Ghimire and Kim's (2018) studies	• This paper also discerns the Lack of Political Commitment as the most hindering impediment

Source: composed by the author based on Luthra et al. (2014), Karatayev et al. (2016), Ghimire and Kim (2018), Wyllie et al. (2018).

As it was mentioned previously, this paper is based on Karatayev et al.'s (2016) work which also scrutinize the renewable energy barriers prevailing in Kazakhstan. The major difference lies in the inclusion of political dimension and its barriers by the author of this paper, while the scholars of previously discussed work do not consider them in the evaluation. It should be also noted that the previously mentioned detection of relationship and interdependence between the barriers in the Karatayev et al.'s (2016) work violates the AHP analysis' axiom about the independence of the properties of the alternatives (Oğuztimur, n.d.). Moreover, after the interaction with one of the experts, some of the barriers were sourced from the other previously discussed studies as well as added by the survey reviewer. Initial barriers, which were taken for the further examination and utilization in the questionnaire, were eventually modified while some of them were removed completely. These changes entail a fresher perspective on the plight of the renewable energy sector in Kazakhstan and identify new barriers that impede the development of sustainable alternatives.

Conclusion

The aim of this paper was to find out which barriers impede renewable energy implementation the most. Before diving into the process of discerning the renewable energy obstructions, the author of this paper had to recognize what costs and benefits of deploying renewable alternatives were. It was found that each source of renewable energy caused certain external costs that have a negative impact on the environment and nearby community. However, the adverse consequences caused by fossil fuel energy have significantly more detrimental effects than the renewable ones, thus, the usage of sustainable alternatives is presented as more beneficial way of electricity generation, although one needs to bear in mind that certain policies discussed in the theoretical part of this paper need to be enacted to minimize the negative exposure of non-conventional energy.

The author of this paper examines previous works done on the identification of renewable energy barriers. The scholars whose works were meticulously scrutinized presented different results on which barriers were posed to be the most hindering in terms of implementation of renewable energy. The dissimilarities in results were reasoned with specificities of each state as well as its current conditions in social, political, and economic dimensions. The works of previous scholars gave a lucid understanding of how the author of this paper wants to conduct the empirical part.

The methodology used in this paper – AHP analysis – enabled to build matrixes based on the survey responses to further construct the ranking of barriers in terms of their obstruction to renewable energy implementation. The ranking of obstacles was done within the respective dimensions; no global weighting was carried out due to a subsequent increase of the survey length that would increase the probability of respondents' abandonment rate and unwillingness to complete the survey in the first place. The author of this paper also reckons that gradual eradication of the barriers in Kazakhstan needs to be done with respect to all dimensions rather than solving the issues in a top-bottom manner.

The result gained with respect to Political dimension in this and Karatayev et al.’s (2016) work implies that Kazakhstan’s contingency on the fossil energy export serves as a severe barrier to the renewable energy development. On the contrary, Indian non-conventional energy sector suffers the most from low consumer awareness. The results with respect to Economic dimension diverge in the studies about Kazakhstan as this paper finds high capital investment to be a major pecuniary impediment, compared to low electricity tariffs. In the case of India, high capital costs also stall the initiation of renewable energy projects. Similarly, the degeneracy of R&D hinders the development of the implementation of sustainable alternatives in Kazakhstan, Nepal, and Barbados. Technological advancements and improvements are crucial to the renewable energy sector as they aid to deploy renewable solutions in a more effective manner with little effects on the environment and human kinds. Low purchasing power and lack of political commitment lead to the stagnation of renewable projects mainly because of people’s unwillingness to pay more for electricity derived from non-conventional energy source and government’s reluctance to support these projects

This paper serves as a good manual to comprehend the current state of the renewable energy sector in Kazakhstan. However, certain improvements can be made to further expand the problem assessed in this study. The increase of the sample size will aid to avoid deceptive statistics in case of the existence of an outlier in the data. Additionally, conducting interviews with the experts will provide the qualitative type of data to gain insights behind the quantitative results. The topic can be further expanded by providing the recommendations on how to curb the renewable energy barriers and what decisions need to be taken to solve the plight of the non-conventional energy sector.

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Appendices

Appendix A

Similarities of the barrier denotations for each respective barrier dimension

Barrier classification	Authors & Year	Examples of barrier denotations
Economic & Financial (financing mechanisms and capital cost)	Luthra et al., 2014	• Lack of financing mechanism • High initial capital cost
	Nasirov et al., 2015	• Limited access to financing • High initial investment costs
	Karatayev et al., 2016	• Lack of access to credit to consumers • High up-front capital costs for investors
	Ghimire & Kim, 2018	• Lack of credit access • High capital cost
	Wyllie et al., 2018	• Large upfront capital costs
Technical (infrastructure)	Luthra et al., 2014	• Lack of local and national infrastructure
	Nasirov et al., 2015	• Grid connection constraints and lack of grid capacity • Inadequate infrastructure to accommodate renewables
	Karatayev et al., 2016	• Lack of infrastructure
	Ghimire & Kim, 2018	• Absence of grid connection
	Wyllie et al., 2018	• System issues (poor installation, poor or no maintenance)
Technical/ Administrative (skilled manpower)	Luthra et al., 2014	• Lack of trained people & training institutes
	Nasirov et al., 2015	• Lack of necessary scientific and technical skills in the workforce
	Karatayev et al., 2016	• Lack of skilled personnel/training facilities
	Ghimire & Kim, 2018	• Lack of skilled manpower (Human Resource)
	Wyllie et al., 2018	• Training & staffing (introduction to expatriates)
Social/ Cultural (social acceptance)	Luthra et al., 2014	• Faith & beliefs
	Nasirov et al., 2015	• Lack of opposition to the development of projects
	Karatayev et al., 2016	• Lack of social acceptance for some RETs

	Ghimire & Kim, 2018	• Lack of social acceptance
	Wyllie et al., 2018	• Social stigma

Source: composed by the author based on Luthra et al. (2014), Nasirov et al. (2015), Karatayev et al. (2016), Ghimire and Kim (2018), and Wyllie et al. (2018).

Appendix B

Survey

This survey is compiled to compare the current barriers prevailing in Kazakhstan that impede the deployment of renewable alternatives. Thanking you in advance for sparing a couple of minutes and filling it out!

Question	Answer
General Information	
Your occupation/academic degree related to renewable energy/energy field	*Answers vary*
Gender	A: Male B: Female
Market Failure Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Fossil Fuel Priority (oil, gas, coal) B: Lack of Consumer Awareness about Renewable Alternatives A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Economic Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Long Payback Period B: High Capital Investment A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: High Capital Investment B: Transmission and Distribution Losses of Electricity for the Particular Period A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance

	6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Transmission and Distribution Losses of Electricity for the Particular Period B: Long Payback Period A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Technical Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Complexity of Using New Technology to Deploy Renewable Alternatives B: Lack of R&D to Improve the Usage of Renewable Alternatives A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of R&D to Improve the Usage of Renewable Alternatives B: Lack of Opportunities for the Professional Training A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of Opportunities for the Professional Training B: Complexity of Using New Technology to Deploy Renewable Alternatives A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance

	4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Institutional Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Weak Legal and Regulatory Framework B: Risky Business Environment A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Risky Business Environment B: Complicated Bureaucratic Procedures A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Complicated Bureaucratic Procedures B: Weak Legal and Regulatory Framework A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Social Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of Consumer Awareness about Renewable Alternatives B: Low Purchasing Power A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7

	7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Political Barriers	
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of Political Commitment B: Lack of Adequate Legislative Framework A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of Adequate Legislative Framework B: Lack of Public Interest Litigations Supporting Renewable Energy Projects A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance
Which barrier is more hindering in terms of deployment of renewable energy alternatives?	A: Lack of Public Interest Litigations Supporting Renewable Energy Projects B: Lack of Political Commitment A = B
How would you rate the intensity of hindrance of chosen barrier?	2 – weak hindrance 3 – moderate hindrance 4 – value between 3 and 5 5 – strong hindrance 6 – value between 5 and 7 7 – very strong hindrance 8 – value between 7 and 9 9 – extreme hindrance

Source: composed by the author

Appendix C

Survey participants

№	Occupation	Field/ Sector/ Project
1	Professor, PhD	Geography - Oil & Gas
2	Engineer	Energy Sector
3	Lawyer	Korday First Wind Turbine Project
4	Professor, MS	Renewable Energy Alternatives
5	Engineer	Korday First Wind Turbine Project
6	Engineer, PhD	Energy Sector
7	Professor	Energy Sector
8	Engineer	Electric Power
9	Engineer	Ereymentau Wind Turbine Project
10	Professor, MS	Energy Technology
11	Engineer	Electric Energy Sector
12	System Engineer	Hydropower Station
13	Professor	Chemistry – Oil & Gas
14	Professor, PhD	Energy Sector & Economics
15	Engineer, MS	Renewable Energy
16	Assistant Professor, MS	Energy Sector & Economics
17	Professor, PhD	Renewable Alternatives Implementation
18	Professor, PhD	Environmental Protection
19	Professor, PhD	Environmental Studies, Consultant in industrial projects at Kazakh Institute of Oil & Gas
20	Engineer, Candidate of Engineering Studies	Energy Sector
21	Engineer	Electric Energy Sector
22	Professor, MS	Electric Power Studies
23	Engineer	Ereymentau Wind Turbine Project
24	Lawyer	Ereymentau Wind Turbine Project
25	Logistician	Energy Transportation
26	Financial Controller	Ereymentau Wind Turbine Project
27	Professor, PhD	Renewable Energy in Economics
28	Assistant Professor, MS	Renewable Energy in Economics
29	Engineer	Electric Power Sector
30	Professor, PhD	Environmental Economics
31	Professor	Prospects of Green Energy Development in the Aral Sea
32	Lawyer	Renewable Energy Projects
33	Physicist	Environmental Studies
34	Logistician	Renewable Energy Logistics
35	Engineer	Oil & Gas Industry
36	Professor	Ecology/ Renewable Energy Development
37	Professor, PhD	Biology – Oil & Gas
38	Junior Engineer	Ereymentau Wind Turbine Project

39	Entrepreneur	Global Business Manager – Oil & Gas Industry
40	Professor, PhD	Electric Power Systems Research
41	Assistant Professor, MS	Electric Power Systems Research
42	Engineer	Energy Sector
43	Associate Professor	Assessment of Potential of Renewable Energy Sources
44	Professor, MS	Energy Sector Strategy
45	Professor, PhD	Alternative Energy and Energy-Saving Technologies
46	Head of Department of Green Technologies	Ministry of Environment Protection
47	Professor, MS	Renewable Energy Technologies
48	Deputy Head	Green Economy
49	Policy Specialist	Environment Protection Technologies
50	Junior Specialist	Energy Efficiency
51	Researcher	Future of Green Energy in Kazakhstan
52	Vice-Chairman	Mangystau Regional Electric Grid Company

Source: composed by the author

Appendix D

Normalized Matrix for Market Failure barriers

Normalized Matrix				
	MF1	MF2	Total	Weight
MF1	0,69	0,69	1,38	69,14%
MF2	0,31	0,31	0,62	30,86%
Total	1	1		100%

Note. MF1 - Fossil Fuel Priority (oil, gas, coal), MF2 - Lack of Consumer Awareness about Renewable Alternatives

Source: composed by the author

Appendix E

Normalized Matrix for Economic barriers

Normalized Matrix						
	E1	E2	E3	Total	Weight	Consistency Measure
E1	0,32	0,30	0,40	1,03	34,19%	3,024
E2	0,55	0,51	0,44	1,49	49,81%	3,032
E3	0,13	0,19	0,16	0,48	16,01%	3,010
Total	1	1	1		100%	
					CI	0,011
					RI	0,58
					CR	0,019

Note. E1 - Long Payback Period, E2 - High Capital Investment, E3 - Transmission and Distribution Losses of Electricity for the Particular Period

Source: composed by the author

Appendix F

Normalized Matrix for Technical barriers

Normalized Matrix						
	TE1	TE2	TE3	Total	Weight	Consistency Measure
TE1	0,33	0,33	0,33	0,99	33,12%	3,000004
TE2	0,39	0,39	0,39	1,16	38,81%	3,000005
TE3	0,28	0,28	0,28	0,84	28,07%	3,000003
Total	1	1	1		100%	
					CI	2,07E-06
					RI	0,58
					CR	3,56E-06

Note. TE1 - Complexity of Using New Technology to Deploy Renewable Alternatives, TE2 - Lack of R&D to Improve the Usage of Renewable Alternatives, TE3 - Lack of Opportunities for the Professional Training

Source: composed by the author

Appendix G

Normalized Matrix for Institutional barriers

Normalized Matrix						
	IN1	IN2	IN3	Total	Weight	Consistency Measure
IN1	0,25	0,23	0,27	0,74	24,80%	3,004
IN2	0,44	0,40	0,38	1,22	40,75%	3,007
IN3	0,32	0,36	0,35	1,03	34,45%	3,006
Total	1	1	1		100%	
					CI	2,755449E-03
					RI	0,58
					CR	0,0048

Note. IN1 - Weak Legal and Regulatory Framework, IN2 - Risky Business Environment, IN3 - Complicated Bureaucratic Procedures

Source: composed by the author

Appendix H

Normalized Matrix for Social barriers

Normalized Matrix				
	SC1	SC2	Total	Weight
S1	0,46	0,46	0,91	45,69%
S2	0,54	0,54	1,09	54,31%
Total	1	1		100%

Note. S1 - Lack of Consumer Awareness about Renewable Alternatives, S2 - Low Purchasing Power

Source: composed by the author

Appendix I

Normalized Matrix for Political barriers

Normalized Matrix						
	P1	P2	P3	Total	Weight	Consistency Measure
P1	0,49	0,49	0,48	1,47	48,89%	3,0003
P2	0,34	0,34	0,35	1,02	34,14%	3,0002
P3	0,17	0,17	0,17	0,51	16,97%	3,0001
Total	1	1	1		100%	
					CI	1,139215E-04
					RI	0,58
					CR	0,0002

Note. P1 - Lack of Political Commitment, P2 - Lack of Adequate Legislative Framework, P3 - Lack of Public Interest Litigations Supporting Renewable Energy Projects

Source: composed by the author

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